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Neighborhood Factors Associated with Physical Activity and Adequacy of Weight Gain During Pregnancy

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ABSTRACT *Healthy diet, physical activity, smoking, and adequate weight gain are all associated with maternal health and fetal growth during pregnancy. Neighborhood characteristics have been associated with poor maternal and child health outcomes, yet conceptualization of potential mechanisms are still needed. Unique information captured by neighborhood inventories, mostly conducted in northern US and Canadian urban areas, has been shown to reveal important aspects of the community environment that are not captured by the demographic quantities in census data. This study used data from the Pregnancy, Nutrition, and Infection (PIN) prospective cohort study to estimate the influences of individual-level and neighborhood-level characteristics on health behaviors and adequacy of weight gain during pregnancy. Women who participated in the PIN study and who resided in Raleigh, North Carolina and its surrounding suburbs were included (n=703). Results from a neighborhood data collection inventory identified three social constructs, physical incivilities, territoriality, and social spaces, which were hypothesized to influence maternal health behaviors. The physical incivility scale was associated with decreased odds (adjusted OR=0.74, 95%CI=0.57, 0.98) in participating in vigorous leisure activity before pregnancy after controlling for several individual confounders, and a crude association for decreased odds of excessive weight gain (OR=0.79, 95%CI=0.64, 0.98). The social spaces scale was associated with decreased odds for inadequate (adjusted OR=0.74, 95%CI=0.56, 0.98) and excessive (adjusted OR=0.69, 95%CI=0.54, 0.98) gestational weight gain. The social spaces scale was also associated with decreased odds of living greater than 3 miles from a supermarket (adjusted OR=0.03, 95%CI=0.00, 0.27). Territoriality was not associated with any pregnancy-related health behavior. None of the neighborhood constructs were associated with smoking or diet quality. Physical incivilities and social spaces neighborhood characteristics may be important to measure to improve our understanding of the potential mechanisms through which neighborhood environments influence health.*

KEYWORDS *Neighborhood context, Pregnancy, Physical activity, Diet, Weight gain.*

INTRODUCTION

Pregnancy is a major life event that is characterized by dramatic physiologic changes and, most notably, rapid weight gain, which has implication for women's health and

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fetal outcomes. Most women, especially overweight and obese women, are more likely to gain gestational weight in excess of the Institute of Medicine (IOM) guidelines and retain that weight after delivery.[1,2] In the last two decades, the average prepregnancy weight has increased with 40% of women entering pregnancy either overweight or obese.[3,4] Weight gained between pregnancies, highly correlated with postpartum weight retention, can dramatically increase subsequent pregnancy complications such as preeclampsia, pregnancy-induced hypertension, gestational diabetes, cesarean section, and stillbirth.[5]

Pregnancy is also an important time period because women change their activity patterns. In addition to the rapid weight gain, pregnancy is an influential life phase because behavioral patterns established during pregnancy may continue through the postpartum period and become permanent habits. These can be health-promoting behaviors, such as smoking cessation, or harmful changes, such as reduced physical activity, both of which influence weight status and general maternal health. Whereas it is well-established that participation in physical activity during pregnancy may prevent excess gestational weight gain[6] and reduce the risk of maternal complications, such as gestational diabetes[7–9] and preeclampsia,[10,11] most pregnant women do not meet the physical activity recommendations. Women with fewer socioeconomic resources are at highest risk of entering and leaving pregnancy with excess weight; they are even less likely to meet the physical activity recommendations[12–15] and are more likely to have poor diet quality during pregnancy after adjusting for individual socioeconomic factors.[16] Women with higher pregravid body mass index (BMI) are at higher risk of poor diet quality.[17]

Smoking is also a modifiable risk factor with well-established harmful effects on fetal growth. Smoking during pregnancy is associated with both low birth weight[18,19] and preterm birth.[20–22] Smoking is associated with lower weight status, lower rates of physical activity, and poor dietary intake in the nonpregnant adult population, thus contributing to the overall weight and health profile of women.[23] Smoking rates are lower among pregnant women than nonpregnant women[24] and decrease slightly during pregnancy.[25,26] Roughly 10–20% of women smoke during pregnancy.[27] Whereas vital statistic reports find a decline in smoking during pregnancy, last reporting a 37% reduction in smoking during pregnancy from 19.5% to 12.2% between 1989 and 2000,[28] smoking has been found to fluctuate widely during pregnancy with a number of relapses.[29] In light of the salience of pregnancy to women's health, it is important to understand the social and physical contexts that may influence health behaviors and outcomes during the pregnancy period.

Neighborhood environments may independently influence physical activity, diet, and smoking behaviors. The independent role of neighborhood context on health behaviors such as physical activity,[30–32] diet,[33,34] and smoking[20,35–37] is of growing interest among researchers. Physical activity is a frequent example of this work, but in the nonpregnant population, neighborhood disadvantage has been inconsistently associated with decreased physical activity.[30,31] Yen and Kaplan found that neighborhood poverty was associated with lower physical activity, whereas Ross found that residents in disadvantaged neighborhoods were more likely to walk, despite reporting a fear of being victimized.[30,31] Research points to one's neighborhood context as an important indicator of nutrition resources and influence on diet quality. For example, low-income neighborhoods have less access to supermarkets[33] and the distance to the nearest supermarket has been negatively associated with diet quality during pregnancy.[34] Using a population-based sample, neighborhood deprivation was associated with increased smoking rates.[35] Smokers

living in deprived areas are less likely to quit smoking.[36] Neighborhood social class was independently associated with smoking in early pregnancy, after controlling for individual socioeconomic status.[37] However, Ahern et al. did not find that smoking mediates the influence of neighborhood deprivation on birth outcomes.[20]

New approaches to assessing neighborhood contexts have recently been developed and promise to more specifically characterize the residential neighborhood environment. Audit tools designed to directly observe neighborhood social and physical conditions have been recently employed in the US, Australia, and Canada.[38–44] These audit tools characterize the immediate residential neighborhood of an individual and are usually more time sensitive than decennial census data. At least one study has found that signs of neighborhood attractiveness, objectively measured characteristics including architectural design, building variety, and vegetation within 400 m of a residence are positively associated with self-reported recreational activity.[41] Using direct observation to characterize neighborhood safety, deterioration or level of social cohesion might clarify the pathway between neighborhood conditions and health behaviors and identify policy-relevant modifiable environmental factors.

To our knowledge, the association between neighborhood context and diet, physical activity, and weight gain among a pregnant population has not been previously explored. The purpose of this paper was to identify how directly measured neighborhood characteristics in Raleigh, North Carolina and its surrounding suburbs are associated with smoking, diet quality, vigorous leisure activity before and during pregnancy, and gestational weight gain for the purpose of identifying possible modifiable neighborhood attributes that may have programmatic or policy implications.

METHODS

Study Sample

Individual data and directly observable neighborhood attributes were collected as part of the Pregnancy, Infection, and Nutrition (PIN) cohort, a prospective study of determinants of preterm birth.[45] Participants were recruited from four prenatal care clinics in two settings: the University of North Carolina Residents' and Private Physicians' Obstetrics Clinics, the Wake County Department of Human Services, and Wake Area Health Education Center Prenatal Care Clinics. Between 1995 and 1999, 3,163 women were recruited into the study at 24 to 29 weeks gestation, of whom 973 reported their last address to be within Wake County. Of these, 703 women whose addresses were within the city limits of Raleigh and its surrounding suburbs were included in the study sample. Sample women were similar to the full cohort with regards to the average number of children, BMI, and smoking status. Compared with the full cohort, women in the study sample had significantly (p value<0.05) fewer years of education (12.5 vs. 13.9 years), were poorer with lower income levels (142.9% vs. 285.2% of the income/poverty ratio), and were younger (24.1 vs. 27.0 years).

Residential addresses were geocoded by Tele Atlas (formerly Geographic Data Technology [GDT]), assigning latitude and longitude coordinates and census unit designations. Neighborhood-level data were collected on physical attributes such as housing condition, commercial property, and observable social interactions. Study procedures were in accord with the ethical standards of the Institutional Review Board of the University of North Carolina School of Medicine and Wake Medical Center.

Data Collection

Individual-level During the recruitment visit (before 20 weeks gestation), women were asked whether or not they currently smoked. At the telephone interview (26–31 weeks gestation), women were asked about demographic characteristics (marital status, race, education, number of children, and income). During the same phone interview, women were asked, "Thinking back to 3 months before you got pregnant until now, have there been times when you have done any regular exercise or strenuous activity like aerobic exercise or jogging at least twice a week?" Women who answered affirmatively were then asked about their level of participation in the most common vigorous leisure activities at any of three time periods: 3 months before pregnancy, the first 3 months of pregnancy, and the second 3 months of pregnancy. Vigorous leisure activities included swimming laps, jogging at a moderate to fast pace, aerobics or aerobic dance, other fast dancing, and moderate to fast bicycling. Women could also report other kinds of exercise or strenuous activity. At 24–29 weeks gestation, women were asked to complete a modified food frequency questionnaire. Eight pregnancy-related foods and nutrients: servings of grains, fruits and vegetables, percent calories from fat, iron, calcium, folate, and a meal patterning score, were used to create an 80-point diet quality index specific for pregnancy.[16] Gestational weight gain was abstracted from medical records.

Neighborhood-level data The Neighborhood Attributes Inventory used in this study was modified from a street survey developed in Baltimore, Maryland to examine how neighborhood factors affected the cognitive and behavioral development of preschool age children.[44] A 39-item survey representing 4 categories of neighborhood attributes (neighborhood physical conditions, social interactions, nonresidential land use [commercial property], and public, residential, and nonresidential space) was developed and is described in full elsewhere.[38]

PIN women were located in 115 of 263 (44%) Wake County census block groups, which formed the sampling frame for street segment selection. Study block groups did not differ from nonstudy block groups within Wake County with regards to the percent of residents who lived in the same house in 1995. Study block groups did have a significantly higher percentage of black residents (32.5% vs. 13.9%), female headed households (15.4% vs. 7.2%), adults without a bachelors degree (15.7% vs. 11.1%), and people at or below the poverty level (14.5% vs. 5.6%) compared to the nonstudy block groups within Wake County. Of all street segments, 20% were randomly selected within the 115 block groups using ArcView 3.2a software (Arcview software, ESRI, 380 New York Street, Redlands, CA 92373-8100, USA). PIN participants' street segments were added to the sample if they were not included among those randomly selected. A total of 2,771 street segments comprised the final sample. Block groups were of variable size; the mean number of block group street segments was 24 (range 6–66 street segments).

Variable Definitions

Individual-level outcome variables A dichotomous variable was created to indicate if the woman reported participating in any of the vigorous leisure activities at each of the three time periods. This variable was defined as any vigorous leisure activity because all of the predefined activities as well as most of the "other" activities required an intensity of at least six metabolic equivalents (METS).[46] A continuous

measure was also created based on the number of hours per week the women reported engaging in these activities. Tertiles of the diet quality index were used in this analysis to distinguish women who had diets within the highest tertile compared to the lowest tertile. Self reported pregnancy weight and measured height were used to construct the BMI (kg/m^2). Recalled pregnancy weight is well-correlated with measured weight.[47] An adequacy of weight gain variable was constructed based on the IOM recommendation for gestational weight gain for each pregravid weight status category.[48] Distance to the closest supermarket was measured in miles and categorized as <1 mile, 1 to 3 miles, and >3 miles. We sought to estimate the association of each scale on distance to supermarket because access to food might mediate the relationship between neighborhoods and diet and/or weight gain. Supermarket location was obtained from the USDA 2000 inspection registry for Wake County, North Carolina and geocoded by GDT. These methods have been previously reported.[38]

Neighborhood definition For this research, neighborhood was defined as the census block group because it represented the smallest census unit that may reasonably approximate one's neighborhood whereas still providing stable exposure estimates. Previous research in perinatal and children's health has found the block group to be an appropriate level of analysis for similar outcomes.[49]

Neighborhood scale development Three theoretically informed scales were constructed based on previous research in Baltimore, Maryland and Raleigh, North Carolina: physical incivilities, territoriality, and social spaces.[38,44] Values were dichotomized by the presence or absence of each attribute for each street segment; the proportion of streets within a block group with the presence of the attributes was then calculated. The maximum score for each scale equaled the number of items in the scale if all streets within the block group had the presence of every item. The first scale, signs of physical incivilities, a combination of physical disorder and poor housing condition, was theorized to communicate decreased local social control and may contribute to an atmosphere conducive to crime and further neighborhood deterioration.[50] Six items comprising the physical incivilities scale include condition of housing, yards, public spaces, vacant or burned property, litter, and graffiti. The second scale, territoriality, comprised six indicators including fences or hedges, decorations, neighborhood, community watch, security warning, and no trespassing signs, which serve as physical and symbolic demarcations of residential property, and are thought to communicate ownership and social control that lead to protective effects against crime and adverse community events.[50,51] The third scale, social spaces, was made up of five indicators including parks, sidewalks, porches, presence of people, and presence of nonresidential visitors (i.e., police, service, and delivery employees). Social spaces are thought to provide local residents communal spaces in which to build relationships and strengthen ties. Scale weightings were estimated using factor analysis and were then converted to z scores for ease of interpretation.[38] The scales were weakly correlated (ρ=<0.4) indicating the scales represent distinct latent constructs.[38]

Statistical methods One-way analysis of variance with Bonferroni multiple comparison test was used to estimate the association between each scale and smoking, diet quality tertiles, any vigorous leisure activity at two time points, adequacy of gestational weight gain, and distance to the closest supermarket. We hypothesized that signs of physical incivilities would be positively associated with smoking and inadequate or

excessive gestational weight gain, and negatively associated with diet quality and physical activity. We did not speculate on the anticipated direction of the associations between territoriality and health behaviors as this construct is a measure of neighborhood social control as a protective mechanism against crime and has only been tested for an association with crime outcomes. We anticipated that the presence of social spaces would be inversely associated with inappropriate weight gain and positively associated with high quality diet and physical activity. Multivariate logistic regression analysis estimated the association between physical incivilities and social spaces scales and any vigorous leisure activity 3 months before and during the first trimester of pregnancy. Multinomial logistic regression analysis estimated the association between physical incivilities and social spaces scales and adequacy of weight gain and distance to the supermarket. Adjusted models initially controlled for variables thought to be exogenous to the relationship between neighborhood factors and vigorous leisure activity, such as maternal age (continuous in years), race (white/other race vs non-Hispanic black), any children (yes/no), marital status (married vs. single), education (≥12 years vs. ≤11 years), and income (>185% vs. ≤185% of income/poverty ratio). A second adjusted model was then estimated that included all covariates from the first model and added any smoking during pregnancy (yes/no) and prepregnancy BMI because they could be on the causal pathway. Finally, a linear regression model was fit using the continuous measure of vigorous leisure activity in hours per week to estimate the change in time spent engaged in vigorous leisure activity with each standard deviation of a scale. In addition, a robust variance estimator was used to account for clustering of neighborhood characteristics at the block group level.[52,53] The robust variance estimator is used for correlated data, for example, one might expect that women living in the same neighborhood (i.e., block group) are more similar to each other in some unmeasured way than they are to women living in a different neighborhood. The robust variance estimator accounts for these potential correlations, being robust to the assumption that observations are independent, resulting in the same point estimate generated from a standard model, but with inflated confidence intervals. Analyses were conducted using Stata 8.2.[54]

RESULTS

Description of PIN Participants

Among the 703 Wake County PIN participants with complete address files, the mean age of PIN participants at conception was 24 years (range 16–40 years). The mean income and years of education indicate that this was a low-income sample (Table 1), 60% had a high school education or less, and the mean income was 142% poverty (range 8–857% poverty). Of the sample, 79% had incomes at or below 185% of the poverty level (the income eligibility criteria for the Supplemental Nutrition Program for Women, Infants and Children (WIC)).

With regards to health behaviors and adequacy of weight gain, 25% of the sample reported smoking during pregnancy. The average diet quality score was 55.2 of a possible 80 points. Only 13% engaged in vigorous leisure activity 3 months before pregnancy (averaging 5.4 h/week [SD=4.6] among those who engaged in vigorous leisure activity), 8% during the first trimester (averaging 3.8 h/week [SD=3.1]), and 3% during the second trimester (averaging 2.9 h/week [SD=2.3]). Because of the low prevalence of vigorous leisure activity in the second trimester, this

TABLE 1 Description of sample

	Number (percentage)	Mean (standard deviation)
Maternal characteristics		
Race		
Non-Hispanic White	191 (27%)	
Non-Hispanic Black	467 (66%)	
Other	45 (7%)	
Marital status		
Married	435 (62%)	
Not married	268 (38%)	
Education		12.5 (2.2) years
>High school	284 (40%)	14.6 (1.5) years
≤High school	419 (60%)	11.1 (1.2) years
Income		142.5 (126.7)
>185% poverty	133 (21%)	323.7 (166.4)
≤185% poverty	505 (79%)	94.8 (45.9)
Maternal behaviors		
Smoking status		
Smoked	186 (27%)	
Didn't smoke	514 (73%)	
Vigorous leisure activity		Among active women
Yes, prepregnancy	94 (13%)	5.4 h (4.6) h/week
Yes, first trimester	57 (8%)	3.8 h (3.1) h/week
Yes, second trimester	20 (3%)	2.9 h (2.3) h/week
Diet quality index tertile		55.6 (12.3)
Low quality	221 (36%)	42.0 (7.7)
Middle quality	195 (31%)	57.4 (2.9)
High quality	206 (33%)	68.6 (4.0)
Adequacy of weight gain		
Adequate	160 (19%)	
Inadequate	130 (23%)	
Excessive	333 (58%)	
Neighborhood characteristic		
Distance to supermarket		1.1 (0.8) miles
<1 mile	350 (52%)	0.6 (0.2) miles
1–3 miles	301 (45%)	1.4 (0.4) miles
>3 miles	19 (3%)	4.5 (0.8) miles

time period was not modeled further. Most women (58%) gained gestational weight in excess of the IOM recommendations and the majority of women (97%) lived within 3 miles of a supermarket.

Indicators of physical incivilities, territoriality, and social spaces varied by neighborhood, and the least frequently occurring indicators were those for physical incivilities (Table 2). The mean value was 1.07 (range 0–3.6) out of a possible six (if all streets within a block group had the presence of each of the six items, the maximum score would be six). The mean values for territoriality (maximum of six) and social spaces (maximum of five) were higher, suggesting a greater presence of indicators for these scales. The values based on the 115 block groups only were then merged with the individual data. The mean values for each scale increased slightly suggesting that more women in the sample lived in block groups with the presence of these indicators.

TABLE 2 Standardized mean scale scores by health behaviors and distance to supermarket

	Incivilities[a]	Territoriality[a]	Social spaces[a]
Block group raw score; mean, SD	1.07±0.74	2.69±0.54	1.45±0.57
(Range)	(0.0, 3.67)	(1.0, 4.25)	(0.57, 3.66)
Sample raw score; mean, SD	1.25±0.77	2.72±0.53	1.51±0.55
(Range)	(0.0, 3.67)	(1.0, 4.25)	(0.57, 3.66)
Sample standardized score; mean, SD	0.21±1.0	−0.04±0.8	0.06±0.7
(Range)	(−1.1, 3.3)	(−2.4, 1.7)	(−1.2, 3.3)
Smoking			
Smoke	0.24±0.96	−0.08±0.78	0.03±0.70
No smoke; ref	0.22±1.04	−0.02±0.76	0.08±0.76
Physical activity prepregnancy			
Vigorous PA, ref	−0.07±0.74	−0.06±0.80	−0.06±0.64
No vigorous PA	0.28±1.05*	−0.04±0.76	0.08±0.76
Physical activity first trimester			
Vigorous PA, ref	−0.10±0.68	−0.06±0.88	−0.07±0.67
No vigorous PA	0.26±1.04*	−0.04±0.75	0.08±0.75
Diet quality index tertiles			
Low	0.24±1.03	0.04±0.71	0.05±0.74
Medium	0.30±1.01	−0.13±0.82	0.05±0.75
High, ref	0.21±1.07	−0.07±0.77	0.15±0.79
Weight gain adequacy			
Adequate, ref	0.29±1.11	−0.06±0.82	0.20±0.85
Inadequate	0.36±0.95	0.02±0.73	0.06±0.74
Excessive	0.06±0.88**	−0.08±0.77	−0.04±0.65*
Supermarket distance			
<1 miles, ref	0.19±1.08	−0.01±0.78	0.10±0.63
1–3 miles	0.32±0.97	−0.06±0.77	0.10±0.86
>3 miles	0.01±0.19	0.25±0.15	−0.64±0.22*, **

[a]Scale scores: low values indicate fewer scale indicators and positive values indicate the presence of many indicators.

*$p<0.05$; prevalence probability compared to referent group.

**$p<0.05$; prevalence probability compared to other nonreferent group.

In bivariate analysis (Table 2) women who did not engage in any prepregnancy or first trimester vigorous leisure activity lived in neighborhoods with a significantly higher mean score for the presence of physical incivilities. Women with excessive weight gain lived in neighborhoods with a lower score for physical incivilities and for social spaces. Women living greater than 3 miles from a supermarket had a lower mean score for social spaces. No statistically significant associations were found between territoriality and any health behavior or distance to the closest supermarket. Therefore, regression models were not estimated for the effect of territoriality on these outcomes. In addition, none of the neighborhood attribute scales were statistically associated with smoking or diet quality. Therefore, these health behavior outcomes were not modeled further.

For physical incivilities, the results of the crude logistic regression models suggest that with each standard deviation increase in the presence of observed signs of neighborhood physical incivilities, there was a 33% and 35% decrease in the odds of engaging in vigorous leisure activity before or during pregnancy, respectively (Table 3).

TABLE 3 Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) for the association between physical incivilities and social spaces and health behaviors and distance to supermarkets before and during pregnancy

	Physical incivilities OR (95%CI)	Social spaces OR (95%CI)
Vigorous leisure activity 3 months prepregnancy		
Crude	0.67 (0.51, 0.88)	0.80 (0.59, 1.08)
Model 1[a]	0.77 (0.60, 0.99)	0.93 (0.70, 1.22)
Model 2[b]	0.74 (0.57, 0.98)	0.90 (0.67, 1.22)
Vigorous leisure activity during first trimester		
Crude	0.65 (0.45, 0.94)	0.79 (0.51, 1.23)
Model 1[a]	0.75 (0.52, 1.10)	0.91 (0.60, 1.40)
Model 2[b]	0.78 (0.54, 1.12)	0.91 (0.59, 1.40)
Inadequate gestational weight gain		
Crude	1.06 (0.83, 1.34)	0.84 (0.67, 1.04)
Model 1[a]	1.10 (0.84, 1.45)	0.75 (0.57, 0.99)
Model 2[b]	1.10 (0.83, 1.44)	0.74 (0.56, 0.98)
Excessive gestational weight gain		
Crude	0.79 (0.64, 0.98)	0.71 (0.57, 0.89)
Model 1[a]	0.86 (0.66, 1.11)	0.70 (0.54, 0.89)
Model 2[b]	0.86 (0.66, 1.11)	0.69 (0.54, 0.89)
1–3 miles from supermarket		
Crude	1.13 (0.73, 1.74)	1.00 (0.65, 1.53)
Model 1[a]	1.21 (0.77, 1.92)	1.05 (0.68, 1.61)
Model 2[b]	1.19 (0.76, 1.87)	1.02 (0.66, 1.57)
>3 miles from supermarket		
Crude	0.82 (0.53, 1.27)	0.05 (0.01, 0.32)
Model 1[a]	0.82 (0.47, 1.43)	0.04 (0.00, 0.47)
Model 2[b]	0.78 (0.46, 1.31)	0.03 (0.00, 0.27)

[a]Controlling for age, education, race/ethnicity, income, any children, and marital status.
[b]Controlling for all covariates in Model 1 as well as smoking and pregravid BMI.

The association between higher neighborhood physical incivility and lower odds of vigorous leisure activity before pregnancy remained after adjustment; the pattern of higher physical incivilities and lower vigorous leisure activity was repeated for the first trimester of pregnancy, but the associations did not remain statistically significant. In a multivariate regression analysis using continuous duration of vigorous leisure activity, the estimate for each increase in one standard deviation score of physical incivilities was a corresponding 12 min less (i.e., 20% of 60 min) of activity per week (−0.20, 95%CI=−0.30, −0.09) at 3 months before pregnancy and it was slightly attenuated to 10 min per week (−0.17, 95%CI=−0.29, −0.05) when controlling for potential confounders. During the first trimester, for each increase in one standard deviation score, there was 4 min less of activity per week (−0.07, 95%CI=−0.14, 0.00); however, the association was attenuated and became non-significant when adjusted for maternal confounders (−0.04, 95%CI=−0.12, 0.04).

With regard to social spaces, although no association was found with vigorous leisure activity, each standard deviation increase in the social spaces index conferred a 25% lower risk for inadequate gestational weight gain and a 31% lower risk for excessive weight gain. A neighborhood with more signs of social spaces was also negatively associated with being farther than 3 miles from the closest supermarket.

DISCUSSION

In this study, we found a positive association between neighborhood physical incivility and not engaging in vigorous leisure activity at 3 months before pregnancy and during the first trimester. Participation in physical activity during pregnancy may assist with optimal gestational weight gain and reduce the risk of maternal complications and adverse pregnancy outcomes.[55] In this sample of low-income and moderate-income women, very few of the women engaged in vigorous leisure activity before and during early pregnancy, 13% and 8%, respectively. This finding is consistent with the population-based work by Petersen et al. who found that between 6% and 11% of pregnant women engaged in moderate or vigorous physical activity.[12] Although none of the neighborhood constructs were associated with diet quality, it appears that a neighborhood with more social space indicators is associated with adequate weight gain and closer proximity to a supermarket. Neighborhood disadvantage may influence physical activity behavior through psychosocial pathways;[56] for instance, perceiving crime or feeling unsafe may deter physical activity.[31,32]

In this study, physical incivilities, territoriality, and social spaces were hypothesized to be importantly associated with reproductive health behaviors in Raleigh, North Carolina and its surrounding suburbs, largely through psychosocially mediated pathways.[56,57] Physical incivilities have been hypothesized to weaken informal social control, which decreases confidence in one's neighborhood to intervene in threatening social situations, which contributes to fear of crime or actual crime.[50,51] The presence of physical incivilities was infrequently observed in Raleigh, North Carolina and its surrounding suburbs,[38] yet residence in a neighborhood characterized by high physical incivilities was modestly associated with no vigorous leisure activity 3 months before and during the first trimester of pregnancy. This may suggest that even low doses of physical incivilities can deter women from engaging in physical activity in their neighborhood. Other research has found that neighborhoods characterized by poor physical environments were associated with decreased physical activity, possibly because of fear of crime.[30] Perceptions of neighborhood safety may be an important piece of information for health professionals to consider when making physical activity recommendations during pregnancy. Whereas perception of safety and crime are very important, social and physical features of the environment need to be addressed to change an individual's perception of the environment.[58]

In this study, indicators of social spaces were hypothesized to have a possible positive influence on engaging in vigorous leisure activity before and during pregnancy through psychosocial mediated pathway and indicators of territoriality, whereas not clearly understood, might convey a positive influence on behaviors through increased social control. However, a null relationship between these measures and engaging in vigorous leisure activity was found. These null findings may result from a variety of sources, including a legitimate lack of association or measurement error. For example, the measure of territoriality includes both positive attributes (i.e., decoration and neighborhood signs) and what might be viewed as negative attributes (i.e., no trespassing and security warning signs) of a community. The combination of both positive and negative features into one scale, despite the appropriate reverse-coding of the variables, may dilute its effect. Another explanation could be that although neighborhoods might exercise informal social control, this might not be enough to overcome perceived obstacles among pregnant women in certain neighborhoods to

permit them to engage in leisure activity in their neighborhoods. A positive association between social spaces and adequate weight gain was found, suggesting that a neigborhood environment characterized by sidewalks, porches, parks and the presence of people may be protective against inadequate or excessive gestational weight gain.

This study has several limitations: First, the PIN study is a clinic-based sample that may not be widely generalizable. Secondly, the vigorous leisure activity items asked were about several activities that women may not carry out in their neighborhood such as swimming, aerobics or aerobic dance, other fast dancing, and moderate to fast bicycling; therefore, these questions may not have been appropriate for estimating neighborhood influences on leisure activity. Questions about walking (i.e., the intensity, duration, and location) might have been a better measure for this type of neighborhood research. Third, because the sample was not randomly recruited to answer study questions about their neighborhoods and health behaviors, selection bias is almost certainly operating. Fourth, social factors associated with leisure activity were not reported, such as having someone with whom to exercise or encouragement to exercise by a significant other.

There are several strengths of this study. First, objective data on neighborhood characteristics, independent of women's perceptions of their neighborhood, were collected to represent neighborhood environment. Secondly, a theoretical foundation for assessing how one's neighborhood might influence leisure activity was used to inform our thinking and analysis on this health outcome. Third, leisure activity data was collected on pregnant women before and during pregnancy, permitting a comparison of individual and neighborhood indicators of physical activity over time.

Physical incivilities and social space characteristics may be important to measure to improve our understanding of potential mechanisms through which neighborhood environments influence health. Although these constructs are theoretical in nature, they comprise social and physical indicators that can be considered for policy and practice interventions.[59] If identified, public health interventions, urban planning, and public policy can address barriers or improve facilitators to increase physical activity within one's residential neighborhood, plausibly improving the health of our pregnant populations.

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